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The Decision-Making Process for Complex Situations in a Complex Environment

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While all decisions are a guess about the future, as complexity builds upon complexity decision-makers must increasingly rely on their intuition and judgment. This chapter explores the decision-making process for complex situations in a complex environment (complex adaptive messes) in terms of: laying the groundwork for decision-making, understanding and exploring complex situations, discussing human additive factors, preparing for the decision process and mechanisms for influencing complex situations. Laying the groundwork introduces the concepts of emergence, the butterfly effect, the tipping point, feedback loops and power laws. Mechanisms for influencing complex situations include structural adaptation, boundary management, absorption, optimum complexity, simplification, sense and respond, amplification, and seeding. The authors forward that decision-makers may be able to construct a strategy that guides problem resolution through a sequence of decisions and actions leading toward an acceptable solution.

Keywords: Decision-Making Process; Decision-Making Journey; Complexity, Complex Decision-Making, Complexity Thinking; Emergence; Butterfly Effect; Tipping Point; Power Laws; Ontology; Feedback Loops; Seeding; Amplification; Boundary Management; Absorption; Simplification; Structural Adaptation; Optimum Complexity; Sense and Respond;

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1. Introduction

Decision-making has been around as long as management and leadership—and probably longer. In the full throes of Bureaucracy, decisions lay fully in the domain of managers and leaders. In 1971, with decision-making still residing in the upper layers of the bureaucratic hierarchy, Chris Argyris described the introduction of "rational" management. This new management approach substituted formal calculation for judgment and instinct, what was then considered personally threatening to the traditional, control-oriented executives. (Argyris, 1971, p. 13) Some authors went so far as to state, "Don't waste an executive's time on decision-making … when it comes to putting data together and making a decision, machines can do a better job than men." (Edwards, 1971, p. 63) By the 1990's decision-makers were well-versed in mathematical and statistical techniques such as utility analysis, operations research, decision matrices and probabilistic decision trees, and had begun to explore the human "qualitative" side of decision-making dealing with probabilities, preferences and propensities. (Sashkin, 1990, p. 17) As our environment continues to become more complex in the increasingly inter-connected world of the 21st century, decision-making has come full cycle. Decision-makers at the point of action (residing at all levels throughout the organization) must increasingly rely on their intuition and judgment. The impact of complexity has not been fully understood, or assessed. Research in complexity science is a relatively young field that has recently become of serious interest to scholars, decision-makers and organizational leaders.

> This research, broadly connected with complexity science, is gathering attention in the business world … as executives and scholars recognize that conventional theories of management, forged in the era of industrialization, vertically integrated companies, and relatively impermeable institution boarders, can no longer cope with the immensely complex organizations that have emerged during two decades of rising globalization and decentralization. (Buchanan, 2004, p. 71)

This chapter explores the decision-making process for complex situations in a complex environment—what we call complex adaptive messes, or CAMs—in terms of: laying the groundwork for decision-making, understanding and exploring complex situations, discussing human additive factors, preparing for the decision process, and mechanisms for influencing complex situations. When the language of complexity thinking is used, it is defined in terms of its usefulness in considering the decision-making process.

For purposes of this chapter, **knowledge** is considered the capacity (potential and actual) to take effective action. We use the term **situation** to mean any issue, problem, condition, opportunity or bounded system that the decision-maker believes needs to be changed, improved, transformed, etc. We interpret this term to mean a complex adaptive system. By a complex situation (problem) in a complex environment we mean one that may be difficult to define and may significantly change in response to some solution; may not have a single "right answer"; has many interrelated causative forces; has no (or few) precedents; has many stakeholders and is often surprise prone. These complex situations may be within an organization, a part of the organization, in the organization's external environment or at the boundaries of two complex systems. Such situations have been referred to as "messes." As Ackoff clarifies, "Managers are not confronted with problems that are independent of each other, but with dynamic situations that consist of complex systems of changing problems that interact with each other. I call such situations messes." (Ackoff, 1978) Messes produce conditions where one knows a problem exists but it is not clear what the problem is. For purposes of this paper, a complex situation in a complex environment will be referred to as a **complex adaptive mess (CAM)**.

Further, we will build on Ackoff's idea of a system of decisions as a set of actions in which the outcome of each action depends on earlier actions and the interactions of those earlier actions, this dependence and interdependence being created by the results of the previous actions and the situation's response. (Ackoff, 1998). We call the anticipated set of decisions and their actions a decision strategy, an approach developed to convert a CAM into a desirable situation. Such a transformation usually requires a a continuing process which must be built into a decision solution by planning a sequence of actions, some in parallel, others sequential, and building pivot points into the strategy to ensure surprise responsiveness. As introduced later in this chapter, this can be thought of in terms of a journey, not a single intervention.

2. Laying the Groundwork for Decision-Making

Every decision has hidden within it a guess about the future. When solving a problem or working toward a goal, we anticipate that if we take a certain action (or series of actions) another situation will result that represents our desired objective. In anticipating the results of this decision/action we are in fact making a guess, howbeit educated or not, about what the consequences will be. This guess has many assumptions relative to the complex situation or its environment, and, as Axelrod and Cohen so succinctly summarize, "The hard reality is that the world in which we must act is beyond our understanding." (Axelrod, 1999, p. xvii) As the problems and messes of the world become more complex, our decision consequences are more and more difficult to anticipate. To keep up with this world complexification our decision-making processes must change.

Complexity is the condition of a system, situation, or organization that is integrated with some degree of order, but has too many elements and relationships to understand in simple analytic or logical ways (Bennet and Bennet, 2004), i.e., the conclusion by Axelrod above. In the extreme, the landscape of a complex situation is one with multiple and diverse connections with dynamic and interdependent relationships, events and processes. While there are certainly trends and patterns, they may well be entangled in such a way as to make them indiscernible, and compounded by time-delays, non-linearity and a myriad of feedback loops. While sinks (absorbers) and sources (influencers) may be identifiable and aggregate behavior observable, the landscape is wrought with surprises and emergent phenomena, rumbling from perpetual disequilibrium. In this landscape, the problem or situation requiring a decision/decision strategy will likely be unique, dynamic, unprecedented, difficult to define or bound, and have no clear set of solutions.

For those unacquainted with the language of complexity, reading the above may sound like intelligent decision-making is a thing of the past. This, of course, is not true. As with any informed decision-making process, we move into the complexity decision space with the best toolset and as deep an understanding of the situation as possible. That toolset may include experience, education, relationship networks, knowledge of past successes and historic individual preferences, multiple frames of reference, cognitive insights, wellness (mental, emotional and physical) and knowledge of related external and internal environmental pressures. The decision space in which the CAM (complex adaptive mess) is to be considered—using relevant decision support processes such as the analytical hierarchy process, systems dynamic modeling, scenario development, etc., and information and technology systems—includes situation and decision characteristics, outcome scenarios, a potential solution set, resources, goals, limits, and a knowledge of political, sociological and economic conditions, i.e., ontology.

Much like fact and logic-based decision processes, the situation elements to be considered in a CAM include perceived boundaries of the system; the ontology of the situation; sets of relevant data and information; observable events, history, trends, and patterns of behavior; the underlying structure and dynamic characteristics of the system; and the identity and characteristics of the individuals/groups involved. Take your favorite decision-making process and add more elements if they appear pertinent. And by all means—always aware of the role of judgment in this process—combine the virtually boundless information harvesting environment of mobile agents with the computational, pattern-matching and storage facilities of decision support systems to uncover as many connections and relationships as possible along with their probabilities of applicability to the situation at hand.

Now, in your informed and reflective state, what is different about making a decision relative to a complex adaptive mess from traditional decision-making? First, consider the following: emergence, the butterfly effect, tipping points, feedback loops and power laws.

Emergence is a global/local (but not micro) property of a complex system that results from the interactions and relationships among its agents (people), and between the agents and their environment. These characteristics represent *stable or quasi-stable patterns*, often qualitative, within a system in disequilibrium that may exert a strong influence within the system. Examples are culture, trust, attitudes, organizational identity, and team spirit. An emergent property is often said to be more than the sum of its parts, although it would be more accurate to say that the emergent property has different characteristics than the sum of its parts. For example, each individual can learn, and so can organizations. However, organizational learning is different than individual learning. Organizational learning requires individuals to work together to accomplish a task with the results created by combining each individual's own knowledge with the capability gained *through their mutual (and often interdependent) interactions*. The same results could not be obtained by adding the contributions of each individual together because the interactions change what each individual knows, learns, and does. It is this interactive gain that produces "synergy" or emergent characteristics of an organization. Thus, the sum of individual learning and organizational learning becomes the total learning of the organization. (Bennet and Bennet, 2003)

The **butterfly effect** occurs when a very, very small change in one part of a complex adaptive system, (or CAM)—which may initially go unrecognized—results in a huge or massive disruption, surprise, or turbulence. These results may be impossible, or extremely difficult, to predict. For example, one small, misunderstood act by a single manager may escalate to a widespread distrust within an organization. A false and untraceable rumor can do great damage to a company's image, or a quiet speech by a president may change the emotional state of a nation.

A **tipping point** occurs when a complex system changes slowly until all of a sudden it unpredictably hits a threshold which creates a large-scale change throughout the system. Examples of this are the stock market crashes in 1929 and 1984, the Cambrian explosion in which hundreds of new species were created in a relatively short time from an evolutionary viewpoint (this occurred about 500 million years ago), and perhaps closer to our focus, when a small company finds itself growing slowly in a niche market that all of a sudden takes off and propels the company to success. The important point about tipping points is that they are typically unpredictable and can significantly change decision outcomes, hence the need for decision strategy flexibility. (Bak, 1996) The results of tipping points are similar to the results of contagious behavior, that is, "ideas and products and messages and behaviors [that] spread just like viruses do." (Gladwell, 2000, p. 7) Ideas, etc. that spread like viruses—taking on a life of their own—are called memes. (Blackmore, 1999)

Feedback loops can either be self-reinforcing or damping, improving a situation or making it worse. In a CAM these often take the form of excitement or an energy surge due to a successful event or perhaps a decrease in morale due to over-controlling management. In turn, management may interpret decreased morale as laziness and put more pressure on employees, creating a dangerous reinforcing loop. In cases such as these, it may be very difficult or impossible to identify the initial cause and effect; typically there are a large number of symptoms, causes, and interactions.

Closely related to tipping point theory are **power laws**. A power law, as used here, is a mathematical relationship that brings together two parameters (measures) within some complex system. For example, the number of earthquakes versus the magnitude of the earthquakes follows a simple power curve. "Double the energy of an earthquake and it becomes four times as rare." (Buchanan, 2001, p. 45). Power laws are further discussed in the section below on Preparing for the Decision Process.

3. Understanding and Exploring Complex Adaptive Messes

As early as 1983, Donald Schon couched the importance of understanding problem setting in terms of the unknown. The problem setting is the process by which we define the decision to be made, the ends to be achieved and the means chosen to implement the decision. In this setting, the decision-maker "must make sense of an uncertain situation that initially makes no sense." (Schon, 1983, p. 40) Schon's example was professionals considering a road to build which dealt with a complex and ill-defined situation in which geographic, topological, financial, economic and political issues were entangled. This means that influencing any one of those areas may well initiate an unpredictable response from another area.

Armed with the realization that all of the information and knowledge gathered to this point lays the groundwork for understanding a complex adaptive mess, the decision-maker tries to be in a position to observe, study, reflect, experiment and use intuition to develop a "feeling" for the key relationships and patterns of behavior within the system. Considering why and how something happens, not just what and when, the decision-maker looks for the structural sources (and the relationships among those structural sources) of multiple actions, interactions, events, and patterns. Trial-and-error perturbations coupled with effortful reflection over time will often provide a deeper knowledge and understanding of how the CAM functions and what it takes to resolve problems. In addition, where possible, talking with people in the system about how the work *really* gets done and who influences what goes on, asking questions and dialoguing to discover their insights, can provide an invaluable sensing capability. The decision-maker is learning how to *feel* the system's pulse through close attention, listening, experience and reflection. This feel for the system is essential since analysis and logic produce useful answers only if their assumptions are correct, and if all material causal relationships can be taken into account—an almost impossible task in a complex system. In a CAM understanding its non-adaptive behavior is inadequate.

Identifying emergent properties can be meaningful, qualitative, global and very informative. One approach to discovering what integrates and creates these emergent characteristics is reflecting on system behavior, history, patterns, properties, events and flows. Patterns are composed of relatively stable sets of relationships and events that occur throughout a system. Since properties are characteristics resulting from interactions within the system and can rarely be reduced to single sources, they must be observed and understood as broad, qualitative phenomena, patterns or underlying structures. An example would be the existence of stovepipes in an organization. Events can result from single, multiple sequential, or simultaneous causes. Decision-makers can consider why they happen, what structural aspects are involved, and any related patterns that accompany the events. Questions to be asked include: Is this the problem or a symptom of a deeper situation? Is the formal or informal structure causing this result? What can be controlled? What can be influenced? What may be nurtured to emerge?

Another approach is to extract patterns and conceptually separate them from the CAM to see how much information they contain and how they influence, or can be used to influence, the complex system.

Analyzing relationship networks can play a useful role in understanding the system and its behavior. Social network analysis (SNA) is an example of this, where you take a complex social system and identify through measurement the relative degree of influence of communication among individuals across the organization. Mapping this provides patterns of information flow and the sources and sinks of influence in the organization, allowing identification of those sources which can most effectively influence the system. Another use of SNA is to map the interactions and relationships among individuals in the organization relative to the influence of individual A's work on individuals B, C and D, and vice versa. This is helpful where people work in relative isolation and yet their work significantly impacts other parts of the organization. That impact often goes unnoticed and individuals think they are doing their job effectively while, in fact, if viewed from a broader systems perspective there is a need for more cohesion, correlation and correspondence.

Developing a potential solution set to a CAM will require a diversity of mental resources. CAMs may need to be studied via both reductionist and holistic thinking, fully engaging decision-maker experience, intuition and judgment to solve problems. This competency to use intuition and judgment to solve problems without being able to explain how they know is a common characteristic of experts. These individuals actively learn through deliberate, investigative and knowledge-seeking experience, developing intuition and building judgment through play and intensive interaction with the system and its environment.

A recent study of chess players concluded that "effortful practice" was the difference between people who played chess for many years while maintaining an average skill and those who become master players in shorter periods of time. The master players, or experts, examined the patterns over and over again, studying them, looking at nuances, trying small changes to perturb the outcome (sense and respond), generally "playing with" and studying the patterns. A significant observation was that when these experts were observed outside their area of expertise they were no more competent than everyone else. The report also noted that, "… the expert relies not so much on an intrinsically stronger power of analysis as on a store of structured knowledge." (Ross, 2006, p. 67) In other words, they use long-term working memory, pattern recognition and chunking rather than logic as a means of understanding and analyzing. This indicates that by exerting mental effort and emotion while exploring complex situations knowledge becomes embedded in the unconscious. By sorting, modifying, and generally playing with information, manipulating and understanding patterns and their relationships to other patterns in CAMs, a decision-maker can proactively develop intuition, insight and judgment relative to the domain of interest. It is through such activities as these that our experience and intuition grow, becoming capable of recognizing the potential unfolding of patterns and the flow of activities in CAMs, leading to an intuitive understanding and a sense of the primary drivers.

4. Human Additive Factors

Issues are not always clear to us because we're just too close to them. As we observe the external world and events around us, we *think* what we do is take our observations, put them into our minds, and thereby have an accurate representation of the external world. Unfortunately, this is not the case. How we view a situation, what we look for and how we interpret what we see depend heavily on our past experience, expectations, concerns and goals.

The potential of the human mind can often be more fully engaged when working in teams, communities and networks, and, when addressing a complex situation, group decision-making can make a large difference. The use of teams to develop multiple perspectives, engaging in dialogue and critical thinking, can improve the overall understanding of a CAM, thereby improving decision strategy efficacy. Of course, this must build on availability and understanding of relevant facts, data, context information and past behavior.

The use of convergent thinking to develop a common team perception of a CAM sets the stage for asking the right questions to identify underlying drivers, patterns and relationships that aid in developing decision strategies and anticipating consequences. Where possible, other approaches such as the use of classic cognitive and operational research techniques (linear extrapolation, mind-mapping, fishbone diagrams, probability distribution functions, etc.) serve as excellent learning tools to develop and share an understanding of the CAM and encourage intuitive insights.

Complexity cannot be easily understood. There is a continuing debate over the nature and definition of the concept (Gell-mann, 1994, pp. 28-30; Rescher, 1998, pp. 1-21; Juarrero, 1999, p. 108; and Schneider and Sagan, 2005, p. 23). Nevertheless, an organization, a team, or an individual must carefully think about, observe, study and become familiar with both complexity in the environment and complexity inside the situation system as preparation for any decision process anticipated. An example is the recognition that complexity in either (or both) the situation and the environment may have a high degree of *variety*. Much of this variety, i.e., the options, actions, choices, and number of possible states that may occur in the CAM, may be irrelevant to the problem at hand and yet require significant energy outlays. There can be too much information, too much variety for the decision-maker to make a decision; thus, the importance of a decision strategy with built-in learning and flexibility. This issue is similar to the information saturation problem which often leads to educated incapacity.

One solution is to ignore those aspects of the situation that are not directly related to the decision-making goals or objectives. While this sounds easy, it may be difficult unless the decision-makers involved have prepared themselves appropriately. For example, in order for a decision team to effectively eliminate some complex parts of a CAM within an organization, they must understand the values and purpose of the organization, the global vision and their own local objectives. They may also need some understanding of the present versus future applicability of various events, actions, opportunities and threats in the environment, the organization and the situation. These are not obvious to decision-makers or knowledge workers because organizations rarely ensure that their people understand these facets well enough to make good decisions by simplification, i.e., by being able to judge *what to ignore* and *what not to ignore*. This takes time; it takes money; it takes learning on the part of managers and workers. It means developing a “feel” for the complex situation. An approach proposed by Espejo, et al, is to ascribe purpose in order to focus a complex problem. “If I am clear about the priorities that really matter to me as an individual and keep these few overriding priorities firmly in mind as I go about my day-to-day activities, this is perhaps the most effective ‘complexity-reducer’ I can employ. It means exercising the self-discipline required to continually hold my organizing priorities in view and refresh or update them regularly. (Espejo, et al, 1996, p. 83)

Often we may find ourselves in confusing situations, ambiguities or paradoxes where we don’t know or understand what’s happening. When this occurs, it is intelligent to recognize the limited mental capacity of a single individual. Confusion, paradoxes and riddles are not made by external reality or the situation; they are created by *our own limitations in thinking, language and perspective or viewpoint*. This is why networks and teams can improve understanding of complex systems. Multiple viewpoints, sharing of ideas and dialogue can surface and clarify confusion, paradoxes and uncertainties to an extent far greater than any one individual mind can do. Other techniques such as lucid dreaming, meditation, heuristics, chunking, gedanken experiments, creative thinking and exploration can improve our capacity to understand and interpret CAMs. See Rock (2004, pp. 152-171) for a discussion on lucid dreaming. See Christos (2003, pp. 149-157) and Tallis (2002) for a recent exposition of the history, role and power of the unconscious in our daily lives.

5. Preparing for the Decision Process

When the traditional decision process is applied to a simple or complicated situation, the objective is to move the situation from the current state to some desired future state. As introduced above, when dealing with complex problems the decision process often requires a commitment to *embark on a journey toward an uncertain future*, creating a set of iterative actions whose consequences will cause a move from the current situation (A) *toward* a desired future situation (B) (see figure). Since there is no direct cause and effect relationship that is traceable from the decision to the desired future state, the journey may require extensive preparation. The decision strategy must have the capacity and internal support mechanisms needed for an implementation journey that cannot be predetermined. The decision-making journey itself, then, could be thought of in terms of complexity. As Auyang describes, “I use complex and complexity intuitively to describe self-organized systems that have many components and many characteristic aspects, exhibit many structures in various scales, undergo many processes in various rates, and have the capabilities to change abruptly and adapt to external environments." (Auyang, 1998, p. 13) The success of this ability to change abruptly and adapt to external environments will be highly dependent on the self-organization and robustness of the adaptive elements built into the decision strategy. The preparation process includes: understanding the domain of interest as well as possible; recognizing the level of uncertainty, surprise potential and nature of the landscape; preparing for the journey in terms of resources, flexibility, partners, expectations, goal shifting, etc.; making sure that individuals carrying out the decision strategy are ready (i.e., sustainability criteria are met); and ensuring that all relevant alternatives have been considered.

In preparing for making decisions that deal with complex adaptive messes, a number of broad competencies may prove helpful. These competencies are not typically part of professional discipline training and education, and therefore may be unfamiliar to many decision-makers. We use the term *integrative competencies* since they provide connective tissue, thereby creating knowledge, skills, abilities, and behaviors that support and enhance other competencies. They also help decision-makers deal with larger, more complex aspects of a CAM, either integrating data, information, knowledge or actions, or helping the decision-maker perceive and comprehend the complexity around them by clarifying events, patterns, and structures.

Managing risk is one such competency, that is, the risk of poor management, leadership or decision-making. Another is an understanding of the basic principles of systems and systems evolution, which provides the ability to look at complex problems from a systems perspective. Another is relationship network management to facilitate the individual developing networks to provide knowledge and cognitive support in building and implementing the decision strategy. Still another one is critical thinking, that is, ensuring that the decision-maker can ask the right questions, including questioning their own assumptions and beliefs, and recognize when information is bogus or nonsensical or simply doesn't fit. Information literacy, another integrative competency, is a set of skills that enable decision-makers to recognize when information is and is not needed, and how to locate, evaluate, integrate, use and effectively communicate information.

We mentioned earlier the importance of becoming comfortable with, understanding, and developing an intuition relative to specific complex systems and situations. As an example of the dangers of *not* understanding complex systems, consider an organization operating in a bureaucratic model where control, policies, and strong decision hierarchies ensure control over workers and a uniform, consistent way of making decisions. This organization is structured such that when a problem comes up, something fails, or someone does something that they shouldn't have, management can quickly step in, make a decision, implement a policy or action, and create another rule which prevents re-occurrence. While this may work for routine, simple problems, it does not work for a CAM because there is no single cause of the problem and no single point of correction. As Battram explains, "Because complex systems have built-in unpredictability, the certainties of the 'command and control' approach to management no longer hold true. The implications of complexity theory for organizations are massive." (Battram, 1996, p. 11)

The standard approach to problem-solving is to: identify the cause of the problem, change it, and the problem goes away. As Sterman describes,

> …people generally adopt an event-based, open-loop view of causality, ignore feedback processes, fail to appreciate time delays between action and response and the reporting of information, do not understand stocks and flows, and are insensitive to nonlinearities that may alter the strengths of different feedback loops as a system evolves. (Sterman, 1994, p. 304)

He cites several studies that indicate that when people tried to control a dynamically complex system their attempts were counter productive. Often, their results were bested by a do-nothing rule. He concludes that, "Subsequent experiments show that the greater the dynamic complexity of the environment, the worse people do relative to potential." (Sterman, 1994, p. 304)

It is clear that the simplistic approach to change does not work if the problem is complex. When this approach is attempted for a CAM, the change often works for a short time, and then the complex adaptive system rejects the change (or works around it) and the problem returns, larger than before. J. W. Forrester, the originator of system dynamic modeling at the Massachusetts Institute of Technology, perhaps said it best when he noted that almost all single actions taken to change an organization result in an immediate response in the intended direction, but after a short time the organization returns to its natural state, sometimes overshooting with a vengeance (Bennet and Bennet, 1996). This is popularly known as counter-intuitive behavior.

As complex systems, organizations (no matter what their structure) have emergent properties such as culture that are created by individuals doing their work, developing habits, procedures, ways of thinking, ways of behaving and ways of interacting with others, all leading to a comfort level that usually facilitates getting the work done. Thus, culture emerges, created by a series of multiple, historical interactions and relationships that evolve over time and take on a life of their own. There is no single force or creator of culture, and there is no single action that will create a specific desired culture. CAMs, while operating in a landscape of disequilibrium, are relatively stable because there is a balance of forces that have created some degree of equilibrium. When you influence part of the system there will be counter forces that try to neutralize the change. Therefore, it takes a set of events and the interactions among those events, far deeper and broader than just a single cause, to change a complex system. While multiple actions, carefully selected and orchestrated, may move the situation toward a desired state, there is no guarantee that the end state will be the one anticipated. However, multiple interventions via a decision strategy may create an environment that nurtures and gently pushes the system to readjust itself in a manner that results in the expected end state. Battram, referring to computer simulations at the Santa Fe Institute on changing a complex adaptive system from the outside, indicates that you have to:

> Create a representation of the interactions in the system and enable the independent agents in the system to communicate about the representation. In the simulations without this representation, the 'agents' simply ignored the outside influences, treating them as mere perturbations. In human terms, you can't simply manipulate a team or a department from outside by telling them what to do. Humans are sense-making organisms: therefore you have to allow them to make sense of the task for themselves by giving them information about the combined results of their actions, and enabling them to talk about it. This is the nitty-gritty of 'holding up a mirror to the organisation'. (Battram, 1996, pp. 254-255)

This approach makes sense in that it recognizes that change can only come from the inside and that people and their relationships, perceptions and beliefs are the major determinants of organizational effectiveness. (Bennet and Bennet, 2004)

Another very important consideration when dealing with complex systems is the ability to make maximum use of your past experience and cognitive capabilities. This means using your unconscious mind (with its memory and associative processing power) to help understand CAMs. For example, we all know much more than we think we know. We are often asked a question that we answer, and yet we didn't realize we knew the answer before the question was asked. We spend our lives soaking up data, information and knowledge, and through our experiences and internal thinking and contemplation, we develop understanding, insights and feelings about things of which we are often unaware. How does this happen? As Churchland observes,

> On those occasions when a weighty decision involves conscious deliberations, we are sometimes aware of the inner struggles, describing ourselves as having conflicting or ambivalent feelings. Some processes in decision-making take longer to resolve than others, and hence the wisdom in the advice to "sleep on" consequential decision. Everyone knows that sleeping on a heavy decision tends to help us settle into the "decision minimum" we can best live with, though exactly how and why are not understood. Are these longer processes classically rational? Are they classically emotive? Probably they are not fittingly described by our existing vocabulary. They are the processes of a dynamical system setting into a stable attractor. (Churchland, 2002, pp. 228-229)

Another aspect of dealing with complex situations is to prepare for unforeseen surprises and rapid jumps. These changes can be of a magnitude far larger than is expected. Some complex systems have the tendency to create surprises which follow a power law. For example, if you look at the sizes of cities in the United States, you'll find that there are many more small ones than large ones, while if you look at the distribution of heights of people in the world you will find a Gaussian distribution with some medium (average) and then some tails on each side of the distribution function. The population of cities in a given country varies according to a power law with the number of cities having N inhabitants proportional to $1/N^2$. Thus there will be 4 times as many cities with a population of 100K as those with a population of 200K. This distribution is quite different than the normal (or bell curve) for Gaussian distribution. The reason this is important is because the tails of the power distribution are considerably stronger, sometimes by a factor as much as 100, i.e. they contain a higher probability of an event occurring than the same tails of the bell curve. A fundamental difference between the two is that the bell curve is based on *the independence of events* that are occurring whereas the power law takes into account that there is some *relationship among those events*. By definition, complex systems are built with multiple interrelationships and therefore have an interdependence that may follow some power law, which has a much higher probability of extreme occurrences happening than does the bell curve. Since CAMs arise out of/within complex adaptive organizations, one might be very cautious in using Gaussian measures within the organization. Interdependence, connections, relationships, connectedness of choices and coherence of actions are mainstays of success in complex adaptive organizations. Therefore, when problems arise, the focus is not just on individuals or policies, i.e., replacing individuals or issuing new policies will not resolve a CAM. As to the significance of power laws in complex systems, consider the case of stock market fluctuations.

> The bell curve predicts a one-day drop of 10 percent in the valuation of a stock just about once very 500 years. The empirical power law gives a very different and more reliable estimate: about once very five years. Large disruptive events are not only more frequent than intuition might dictate, they are also disproportionate in their effect … most of the total movement in any stock over a single year is often attributable to abrupt changes on a few select days." (Buchanan, 2004, p. 73)

A decision strategy may be to charter a team to work with the CAM, preparing the team to react quickly to surprises. Quick reactions on the part of the team in dealing with surprises or unknown, even unanticipated, opportunities can make a huge difference in the success of the effort. The ability to react quickly does not come automatically. It must be *deliberately infused* into the solution set and *supported* by managers and leaders such that the team has the experience, freedom, responsibility and accountability that allows them to react quickly to externally created opportunities and threats. This means, for example, that *self organization and empowerment* may be important factors in the solution team's success. This means open communication so that team members who face a problem at the point of action understand the decision direction and intent, and have the ability and freedom to talk to anyone within the problem domain—and perhaps even external to that domain when needed—to quickly access information and expertise to assist in handling surprise events or opportunities.

In addition to quick reactions, there's also the idea of team flexibility. Flexibility means the capacity to learn to maintain an open mind, not prejudiced by past success and bureaucratic traditions or rigorous thinking; the ability to assess an occurrence in the environment objectively; and the wherewithal to take whatever rational action makes sense—either on the basis of logic or intuition and judgment—to achieve decision-making goals. This flexibility means that decision-makers must be willing to try new approaches, moving beyond conservative solutions that have proven themselves in the past, and be willing to take risks in new areas where outcomes are uncertain (at best) and perhaps completely unknown (at worst). This also means that people must be capable and willing to work with each other, work with others they have not worked with before, work in new ways, and take unfamiliar actions. All of these aspects deal with flexibility, whether it's organizational, team, cognitive, social or resource flexibility.

A final item on the check-off list of team health needed to implement a decision strategy is adaptability. By this we mean the capacity of the team to significantly change its internal structure as needed to resolve the CAM. Adaptation may not be a small flexible change; it could be medium to large-scale internal structural changes resulting in more effective interfaces and interactions across multiple stakeholders. Solving a CAM may become a negotiated compromise with the result being a mutually beneficial co-evolution of the situation and the decision-maker's organization. It becomes clear as we look at the corollary consequences of decision-making relative to CAMs that decision-making is directly tied to implementation, and that the organization and the complex situation may not be separable.

In summary, to prepare there are many things that individuals and teams can do to understand the complex environment more effectively, and there are actions and approaches that can improve the chance of success. In addition, there are actions that a team or an organization can take regarding its own structure and processes that will support decision-makers in dealing with CAMs. None of these actions or approaches can occur quickly since they are not naturally self evident to workers who have not had experience in changing CAMs. Thus, a considerable amount of "new learning" may be involved in rethinking the perspectives of what the organization really is, what complexity means, and how to orchestrate a change in behavior. While learning and understanding are the first step, next comes changing behavior, changing modes of thinking, and changing how you approach problems, which are equally important, and often more difficult. The decision to put resources and time into creating a solution strategy and team which has the capability of quick reaction, flexibility, resilience, robustness, adaptability, etc., is a very tough question for leaders and managers who think predominantly in terms of the bottom line and are unfamiliar with the potential ramifications of complex problems.

6. Mechanisms for Influencing Complex Situations

A theory is a generalized statement about reality that describes how things relate to each other in a given domain of inquiry. A theory provides a foundation for understanding why things relate and what specific causality exists. Thus, in trying to understand or generate a decision strategy for a specific CAM, one not only needs rules, patterns and relationships but also the underlying theories, principles and guidelines (where available) to allow generalized knowledge creation from and application to the specific situation. This generalization may be quite challenging for complex problems, which may not repeat themselves within a semblance of coherence. However, before the mind can effectively observe, reflect and interpret a situation in the external world, the frame of reference of the decision-maker must be recognized since that frame will define and limit what is sensed, interpreted and understood. Multiple frames of reference serve as tools to observe and interpret the system from differing perspectives, providing the opportunity to find the best interpretations and explanations of the complex situation.

To find a frame of reference applicable to complexity requires an appropriate language, a set of concepts and ways to characterize the situation. For example, without an awareness and understanding of concepts such as the tipping point, butterfly effect, emergence, feedback loops, power laws, nonlinearity, etc., it is difficult to have a frame of reference which would adequately recognize and permit an integrated view of a complex situation. Thus, rather than intelligence or brilliance, it is more likely to be homework, learning and "some experience living with the situation" that guides the decision-maker through the landscape and subtle underlying patterns that facilitate an interpretation of the future of a complex situation. We begin.

The **ontology** of the decision process represents the schema or set of characteristics and conditions surrounding the decision strategy that potentially have an important influence on the desired outcome. To the extent that these factors may be identified, they can then be prioritized, rated for significance, visualized through graphics and used to develop the optimum decision strategy. For example, if an organization is unable to perform well in a rapidly changing, uncertain environment its senior leadership may decide that the Intelligent Complex Adaptive System (ICAS) organizational model may be the best solution. If so, the ontology would consist of the eight emergent characteristics of the ICAS model, namely: organizational intelligence, unity and shared purpose, optimum complexity, selectivity, knowledge centricity, permeable boundaries, flow and multidimensionality. The decision strategy would then be to change the current organization to encompass these eight emergent characteristics—ranked and weighted by their importance to the specific products, markets, mission, etc. of the organization—by building a set of actions that would move the organization toward the desired state.

When the complex situation/problem lies within the decision-maker's own organization, special considerations come into play. It may become necessary to view the problem as part of the organization in the sense that both "systems" are complex and interconnected. As Stacey, et al describes, "Thinking in terms of interconnections and the consequent awareness of causal links that are distant in space and time alerts managers to the unintended and unexpected consequences of their action." (Stacey, et al, 2000, p. 80) In other words, the organization may be *part of the problem* and any successful solution would include changes both inside the "problem" as well as in the surrounding organization. In a sense we have two coupled complex systems that are connected such that any change in one is likely to affect the other. Since such structural coupling or adaptation is common, the decision strategy may be to use this coupling to pull the problem situation along in the desired direction. In general, **structural adaptation** is a good way to influence complex organizations, although exactly where it will end up cannot be predicted. For detailed analysis of structural adaptation see von Krogh and Roos (1995) and Maturana and Varela (1995).

Boundary management is a technique for influencing complex situations by controlling/influencing their boundary. For example, if a vendor is providing medium quality products to a manufacturing plant, the buyer may change the boundary conditions (purchase price, delivery schedule, quantity, etc.) to press the vendor to improve quality, forcing the problem into the vendor's system. Changing the information, funding, people, material, or knowledge that goes into or out of a complex situation will impact its internal operation and behavior. For example, using the external media as a vehicle for effectively communicating the importance of internal organizational messages. Such indirect actions may prove more effective than direct intervention. Complex system behavior is usually very sensitive to its boundary conditions because that is where the energy comes from that keeps it alive and in disequilibrium.

Absorption is the action to bring the complex situation into a larger complex system so that the two slowly intermix, thereby resolving the original problem by dissolving the problem system. This may happen during a merger or takeover. A related approach is for two organizations to swap people such that each learns from the other and brings back ideas, processes and insights. In this way, workers in a "problem" environment can experience and learn from a "desirable" environment.

Another approach to dealing with a complex problem is embracing complexity. Consider the creation of **optimum complexity** as a tactic for the decision-maker. Ross Ashby's law of requisite variety states that for one organization or system to influence or control another, that the variety of the first organization must be at least as great as—if not higher than—the variety of the controlled organization. (Ashby, 1964) This comes from Cybernetics, and is more of a rule than a law, but very useful when dealing with complex problems. What it means is that your decision strategy should have more options available than the CAM you are dealing with. By building more complexity into the decision strategy—finding more alternatives for action, pivot points, feedback networks, etc.—you are better able to deal with the unpredictable responses that may arise during implementation. See Axelrod and Cohen (1999) for an extensive treatment of the role of variation, interaction, and selection in dealing with external complexity by embracing internal complexity within an organization.

Simplification reduces our own uncertainty, makes decisions easier, and allows logical explanations of those decisions. Simplicity captivates the mind; complexity confuses and forces us to use intuition and judgment, both difficult to explain to others. As humans we tend to continuously simplify to avoid being overwhelmed, to hide confusion, and to become focused and efficient. In a simple, predictable world this is rational and generally works well. It is easy to ignore many incoming signals when we know they are not important. Unfortunately, in a complex situation and environment this approach can become dangerous, perhaps even disastrous. As Murray Gell-Mann states,

> One of the most important characteristics of complex non-linear systems is that they cannot, in general, be successfully analysed by determining in advance a set of properties or aspects that are studied separately and then combining those partial approaches in an attempt to form a picture of the whole. Instead, it is necessary to look at the whole system, even if that means taking a crude look, and then allowing possible simplifications to emerge from the work." (Battram, 1996, p. 12)

Where complexity lives, it is hard to separate the unimportant from the critical information, events, or signals. The question becomes one of what aspects of this complex situation can be simplified, and how does that simplification benefit the overall solution set?

Sense and respond is another strategy to deal with CAMs. This is a testing approach where the problem is observed, then perturbed, and the response studied. This begins a learning process that helps the decision-maker better understand the behavior of the CAM. Using a variety of sensing and perturbations provides the opportunity to dig into the nature of the situation/problem before taking strong action. This tactic is often used by new managers and senior executives who wait, watch and test the organization before starting any change management actions.

Closely coupled to the sense and respond approach is that of **amplification**, used where the problem is very complex and the situation's response is unknown. This is the evolutionary approach where a variety of actions are tried to determine which ones succeed. The successful actions are then used over and over again in similar situations (the process of amplification) as long as they yield the desired results. When actions fail, they are discarded and new actions are tried; time is unlikely to help failed actions succeed because of the unpredictability of the future. Many trial actions will have a short half-life. This is not blind trial-and-error experimentation since decision-maker learning occurs continuously and judgment, experience, and deep knowledge can create understanding and knowing that result in more effective actions. In other words, sense and respond, trial and error, and amplification used both as part of a decision strategy and learning tools—coupled with a knowledge of complex systems, the use of teams, and the deliberate development of intuition—suggest a valuable approach to dealing with complex systems

Seeding is a process of nurturing emergence. Since emergent properties arise out of multiple nonlinear interactions among agents of the system (people), it is rarely possible to design a set of actions that will result in the desired solution? However, such actions may influence the system such that the desired emergent properties, outcomes, or something close to them, will emerge. *Emergence is not random*. It is the result of the interaction of a variety of elements and, if we cannot predetermine the exact emergent property, such as a specific culture, we may be able to create a culture that is acceptable—or perhaps better—than the one we believe is needed. If we can find the right *set of actions* to move a problem in the right direction, then we may be able to guide the situation to our intended outcome. Such a journey is the decision strategy.

7. The Challenge

The typical or traditional language of decisions implies a causal and deterministic connection between the decision and the end goal, whereas with complex systems there may be no predictable end goal and no direct causal connection that works. However, we have forwarded that one may be able to construct a decision strategy that guides problem resolution through a sequence of decisions and actions leading toward an acceptable solution. Such a plan might include (or anticipate) acts of seeding; boundary management; key success factor influence; identification of sources, sinks and regenerative loops; tipping points and butterfly effects; stability patterns; emergence flows; and miscellaneous external perturbations. While each of these has their own causal impact, the complexity of the system prohibits predicting their paths. Relative to stable pattern formats, i.e., emergent phenomena, though one cannot identify the sources of its creation, nevertheless *everything is exactly as it should be*. Hindsight is 20/20; foresight is closer to 400/400.

By studying specific complex systems we seek to create an intuitive and unconscious capacity to understand their behavior and meaning. We know that systems are often combinations of simple, complicated and complex segments. This has both advantages and disadvantages. While the simple and complicated aspects can be dealt with via normal decision processes, their success can lead decision-makers to assume that the same approach applies to complex situations. And, of course, complexity and complicated parts of the system are frequently intermixed. Since rational decision-making can be developed and has a historic precedence most individuals rely on logic with its supporting data and information to make and defend their decisions, even if problems are complex. In fact, it seems probable that most rational decisions that fail do so because they have not accounted for the complexity of the problem. And, of course, some rational decisions have turned out to be right not because they were logically accurate but because of the complexity of the problem. It remains to be seen how or if it is possible to take a complex situation and identify these separate aspects of the system in such a way that one could choose the most effective decision strategy.

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